

Snowmass TDAQ Subgroup Update

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Currently planning for three (four?) white papers

“Artificial Intelligence and Machine Learning in Trigger and DAQ”

- Big and popular topic, so depending on community feedback consider split to two white papers? e.g. “AI/ML at the edge” and “AI/ML in High-level triggers, event-filtering, and detector control”
- Work closely with IF07 (especially on the former) and computing frontier (especially on the latter)

“Innovating Trigger and DAQ for the next generation of detectors”

- Include TDAQ architecture and infrastructure (e.g. streaming DAQ), fast computation on heterogeneous computing, fast timing, trigger-aware ASIC development (work with IF07)
- Natural place for ideas not specific to AI/ML (e.g. fast tracking triggers, fast spectral analysis), and a way to tie-in needs of future experiments

“Readout technologies for future detectors”

- Include wireless readout, rad-hard links, multiplexed high-speed readout (with IF7)

Next steps

Finalize reaching out to all LOI authors

Include two suggested ML-oriented ‘orphans’ from the list (#061, #084), though both seem more geared towards offline applications

Reach out to TDAQ group as a whole as well, to advertise this plan, along with the plans for a ‘pause/slowdown/etc.’

Work towards assigning editors

Have ideas, but considering timing of this: would it be better to formalize ‘editors’ after we come out of the ‘pause’?

Backup

Real-time processing hardware

- System on chip/readout-integrated ASICs for triggering, feature extraction, self-calibration, etc. (Mostafanezhad et al., Miryala et al., Miller et al 132)
 - Miryala discusses some specific issues, like non-volatile memory and co-design
 - Miller highlights need for Multi-Processor SoC and FPGA for DL/AI needs
- FPGAs for ML inference (Miller et al 132, Herbst et al)
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Triggering techniques/algorithms

- Charged-particle track trigger algorithm in FPGA (Kotwal)
- *Self-driving triggers* for automated/adaptive data selection (Miller et al. 72)
- *Real-time adaptive deep-learning* with embedded systems (Miller et al. 132)
- Extending scalable readout systems (SRS) for better/more programmable triggering (Muller et al.)
- Asynchronous L1 triggers for Colliders (Acosta et al.)
 - Requires precise/synchronized/stable timing
- Non Von-Neumann neuromorphic computing (Miryala et al., 180)
 - Overlaps with Event-driven processing

TDAQ AI/ML focused LOIs

- Inference applications
 - Fast inference, heterogenous acceleration, ML as a service (Acosta Flechas et al., 128)
 - FPGA-based edge AI (R.Herbst et al., 121)
 - High speed instrumentation for front-end DAQ (Mostafanezhad et al, 132)
- New techniques
 - Non Von-Neumann neuromorphic computing, non-volatile memory (Miryala et al., 180)
 - Self-driving trigger for automated/adaptive data selection (Miller et al, 72)
 - Real-time adaptive deep-learning with embedded systems (Miller et al, 132)
- Experiment focused needs:
 - DUNE, low energy events (Balantekin et al, 167)
 - Project 8, tracking (Oblath, 46),

Data links/readout

- Wireless
 - Data transfer for Colliders (Zhang et al. 4)
- Rad-hard links
 - Photonics-based links (Zhang et al. 7)
- Wavelength division multiplexing (Garcia-Sciveres et al)
 - Also with photonics chips in detector

Experiment/detector-specific DAQ needs

- Project 8 DAQ (Oblath)
 - Real-time spectral analysis and tracking for trigger/data reduction (compute-intensive)
- Low-energy events in DUNE (Karagiorgi et al.)
 - Largely improved algorithms and data compression to extend low-energy sensitivity
- Belle-II upgrades (Vahsen et al)
 - DAQ upgrades underway for increased rates, timing upgrades envisioned for long-lived particle triggers(?)
- Optical instrumentation for EM calorimeters (Rutchi et al)
- Muon Scintillator R&D for Higgs factory/long-lived particle searches (Wang et al)
- Large Scintillator Arrays (Young et al)
 - Signal coincidence and >100 ps timing resolution (for position reco)
- TRACK-BASED TRIGGERS FOR EXOTIC SIGNATURES (Holmes et al., 8)

Additional items

- This is must but not all of the LOIs: particularly, still reviewing the LOIs submitted outside the IF
 - Includes mostly some summary LOIs for future experiments (e.g. PUMA, Mu2e), and Fast ML for triggering and computing frontier: still needs a closer read/look for synergies to other efforts
 - These ones may be the more surprising ones for us, but on brief look looks as expected
- We had a lot of good discussion on related/different items at workshop before the LOI deadline
 - Minutes:
<https://docs.google.com/document/d/17Bqt2NUEWjjmTtOYp6YqVAGdYD4JhHc3SiSpWtKm4M4/edit?usp=sharing>

Topic/Category Ideas

- ✓ Use of AI/ML in TDAQ
 - Lump everything together first, and see where the natural splits arise?
- Discussion/coordination with IF07
 - Trigger-aware ASIC development
 - Include links? Specialized hardware? Ties to readout bandwidth
 - → need to discuss with IF07 and cross-cutting group on how to push forward
 - Readout technology for the next generation of detectors
 - Wireless, rad-hard,
- ✓ Streaming DAQ, “Triggerless” systems, fast computing and processing for trigger needs: both ‘off-the-shelf’ and custom (computing model, heterogeneous hardware, parallelization, track trigger specifically, fast spectral analysis for large arrays?, AI/ML connections)
- Hopefully above leads to ... TDAQ Infrastructure/architecture: Asynchronous at the first level, control/signals for large distributed systems, “IOT”
- Fast timing and synchronization/distribution to front-end electronics
 - Maybe followup with liaisons/other frontiers and ask for related LOIs